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Proposal to Process and Analyze LCC Crashback Propeller Deformation Data

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14. ABSTRACT
A DDPIV system was designed and constructed to work in the LCC. A large set of 3D images were taken during two weeks of testing at the LCC in April. The most important cases have been processed, and some of the previously processed cases were re-processed to include the time dependence of the blade deflection. This extra information will be used to better remove the apparent blade motion coming from errors in strobe synchronization.

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DDPIV, 3D imaging,Blade deflection

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Also, please save the file using the contract name as the file name (e.g. N00014-96-C-0387.doc). Instructions on sending the finished file are on the web site w3.sainc.com/onr33

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Contract Information

Contract Number	Number N00014-10-1-0128
Title of Research	Proposal to Process and Analyze LCC Crashback Propeller Deformation Data
Principal Investigator	Professor Mory Gharib
Organization	California Institute of Technology

Technical Section

Technical Objectives

Our objective was to measure the blade deflection of a flexible propeller in crashback at the Large Cavitation Channel (LCC). Our group used our Defocused Digital Particle Image Velocimetry (DDPIV) system to measure the blade shape optically while the blade was being spun on the open water dynamometer. A large set of 3D data was taken during the test and was processed to measure blade deflections under varying conditions.

Technical Approach

Blade shape measurements were made using our DDPIV system. This consisted of a video camera with a specially modified lens, which allowed us to make continuous 3D measurements of a dot pattern painted on the surface of the propeller blades. Lighting was provided by a bank of strobe lights from Carderock, whose timing was synchronized with the propeller and our camera. This allowed us to make dynamic measurements of the blade shape as it varied under unsteady loading.

Progress Statement Summary

A DDPIV system was designed and constructed to work in the LCC. A large set of 3D images were taken during two weeks of testing at the LCC in April. The most important cases have been processed, and some of the previously processed cases were re-processed to include the time dependence of the blade deflection. This extra information will be used to better remove the apparent blade motion coming from errors in strobe synchronization.

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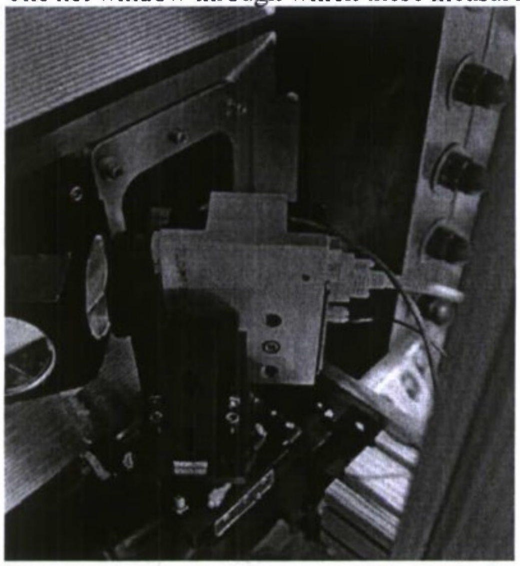
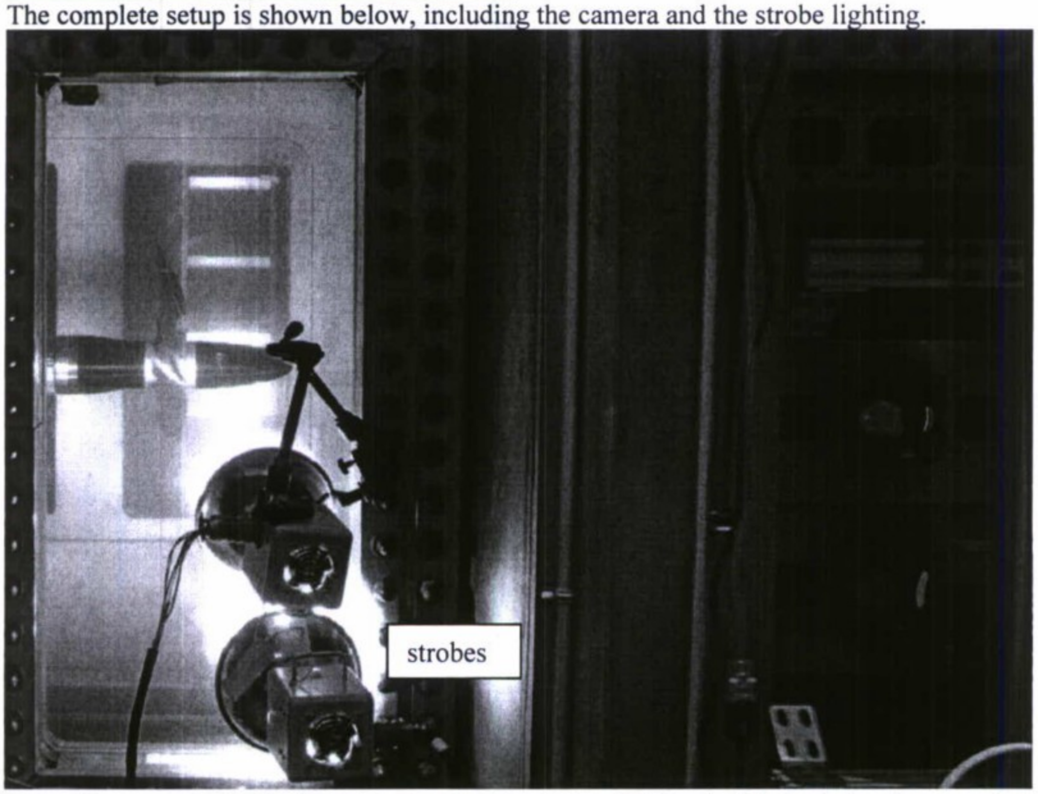
Progress

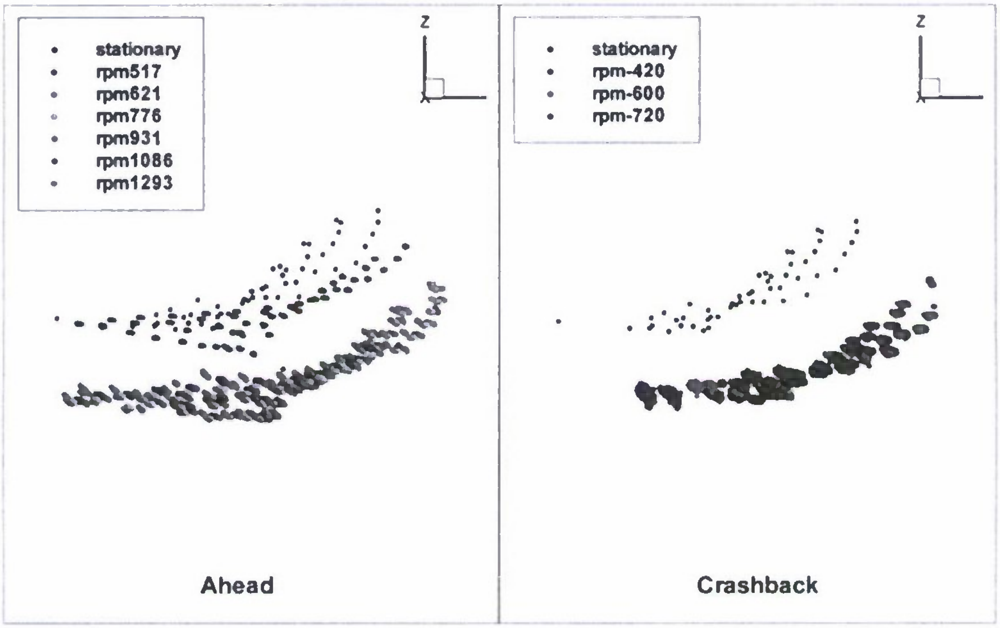
Construction: A DDPIV system was designed and constructed in time for the April test in the LCC. Our group needed to build a custom modified lens for this test, which would give the desired field of view and accuracy needed for the deflection measurements. The camera is shown below, mounted on the side of the test section of the LCC. In order to look at the entire face of the blades, the camera needed to be mounted at a sharp angle. This necessitated the use of a water prism to eliminate the distortion due to refraction. The net window through which these measurements were taken was about three inches in diameter.



The complete setup is shown below, including the camera and the strobe lighting.



Data: The second phase of data processing has been completed. This includes the propeller in ahead and crashback conditions at a variety of J & RPM combinations. We are currently discussing with the rest of the project team at Carderock on how to best make use of the data. An example of the data is shown below. Each cloud of dots is every marker point for each condition (50 points in ahead conditions, 192 in crashback). The black dots were for a stationary blade, as reference. The points show how the blade flexes and twists with changing RPM.



To illustrate the synchronization problem, the plots below show 25 time steps of the propeller blade deflection. The left plot is face on, and the right plot is a sideview. The time steps are expanded along the Z axis for clarity. If there was no synchronization error, the face on plot would show a single dot, rather than the wavy S shaped curve, and the sideview plot would show a straight line. The data were originally compiled as one time averaged set, but they have been reprocessed to separate out the time component to facilitate registration.